STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources

BULLETIN No. 144-69

RADIOLOGICAL APPLICATIONS PROGRAM

Annual Report for FY 1968-69

December 1969

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

Measuring soil moisture depletion of plum trees with nuclear moisture gauge.

STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

BULLETIN No. 144—69

RADIOLOGICAL APPLICATIONS PROGRAM

Annual Report for FY 1968—69

Copies of this bulletin at $1.00 each may be ordered from:
Office of Procurement
DOCUMENTS SECTION
P.O. Box 20191
Sacramento, California 95820
Make checks payable to STATE OF CALIFORNIA.
California residents add 5 percent sales tax.

December 1969

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

Foreword

This second report in the Bulletin No. 144 series covers activities of the Department of Water Resources' radiological applications program during the 1968-69 fiscal year.

The term "radiological" pertains to the study and use of atomic energy in the form of radioactive isotopes and X-ray apparatus. The Nuclear Engineering program of the Department was initiated in 1958, pursuant to House Resolutions 88 and 234, 1957 California legislative session. H.R. 234, among other provisions, directed appointment of a Subcommittee to ascertain, study, and analyze all facts relating to "....development in the general field of peaceful use of atomic energy as these may relate to California water problems;..."

Clearly, the Legislature intended that the Department assume an active role in studying and developing nuclear energy applications - primarily power for project use, but in a broader sense all applications that might benefit water resources development. These include radiological applications.

The term "program" as used herein differs from the conventional meaning of the word in Department usage. The radiological applications program in itself is not productive of a result such as a plan, a design, or a recommendation for development of a water resource. Rather, it applies to the application of nuclear phenomena as an aid in measurement, identification, tracing, or detection, and is thus a tool to be used in Department investigative programs or construction projects. Typical among such programs or projects are vegetative water use, soil salinity investigations, and nondestructive inspection of construction materials.

This report includes brief descriptions of studies, investigations, and tasks related to water resources in which radiological applications have played a part and may continue to do so in the future.

This report series is intended to keep those concerned with planning and development of water resources and the operation of water projects currently informed on radiation-related activities.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
November 26, 1969

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

RONALD REAGAN, Governor
NORMAN B. LIVERMORE, Jr., Secretary for Resources

WILLIAM R. GIANELLI, Director, Department of Water Resources
ALFRED R. GOLZE , Deputy Director
JOHN R. TEERINK, Deputy Director

POWER OFFICE

James K. Cummings ..... Chief

This report was prepared under
the direction of

Maurice B. Andrew ..... Chief, Nuclear Unit

by

Irving Goldberg ..... Associate Soils Specialist (Radiologic)
Radiological Operations Officer

CONTENTS

ILLUSTRATIONS

Acknowledgments

The assistance provided by public agencies in helping to further the Department of Water Resources' radiological applications program has been singularly valuable. It has aided the Department in pursuing a more extensive program of study and application than otherwise would have been possible. For the cooperation and counsel provided by the following agencies, the Department is particularly appreciative.

California Department of Public Health
Bureau of Radiological Health

California Department of Industrial Relations
Division of Industrial Safety

California Division of Highways
Materials and Research Department

University of California at Davis
Department of Water Science and Engineering

U. S. Forest Service
Pacific Southwest Forest and Range Experiment Station

U. S. Department of Agriculture
Agricultural Research Service

U. S. Department of Interior
Bureau of Reclamation

U. S. Department of the Army
Corps of Engineers

U. S. Atomic Energy Commission
E. O. Lawrence Radiation Laboratory

In addition, the Department appreciates the cooperation of the many individuals and the private organizations who gave generously of their time for consultative services and from whose experience in this emerging science the Department has benefited greatly.

Conclusions

Water resources development is a field in which the unique properties of radioisotopes have found many applications. Such uses have resulted in improving conventional practices and in making possible new measurements unachievable by other means. Probably the application most beneficial to the Department is the use of radioisotope gauging devices for determining moisture content and density of granular materials, such as soils. These devices have contributed significantly to the improvement of accuracy and dependability of soil moisture and density measurements. The Department's investigations of vegetative water use and compaction control have been particularly aided by utilization of nuclear moisture-density gauges.

Investigations in which radioisotopes are used as tracers have shown promise of revealing information which cannot be obtained by any other known techniques. An example is the knowledge of sediment drift gained by using radioisotopic tracers to follow the movement of offshore underwater sediments. Use of radioisotopes to measure fluid flow and to rate pumps and turbines has shown potential value as an alternative to the conventional methods used by the Department. These applications are worthy of continued evaluation. No immediate needs are foreseen for nuclear explosives, but this is a technique that may ultimately find some application in excavation or ground water resources development.

The widespread application of sealed radioactive sources to inspect construction materials is an unquestionably valuable technique in the Department's construction program.

Because the use of radioactive material is subject to regulatory and licensing control, a radiation protection program has been developed as an adjunct to the applications program. This auxiliary program has functioned so successfully that since it began about ten years ago thousands of man-hours have been spent in handling potentially hazardous radioactive material without a single reportable instance of personnel overexposure.

Abstract

The atom has been put to work, and its manifold benefits demonstrated, in many of the widely divergent activities carried out by the Department of Water Resources. Described in this report are radiological techniques which have been applied to more than 10 investigative programs of the Department or of other agencies with which the Department has cooperated. These uses range from development of a device to measure soil compaction in earthwork construction to determination of the suitability of a wildlife habitat - from making in-place measurements of the physical properties of a snow bank on a mountain top to following the offshore movements of drifting sand at the bottom of the ocean.

In addition to describing the beneficial uses to which radioisotopes have been put, the report discusses several possible future projects connected with departmental functions which might be benefited by radiological applications. Among these are large-scale excavation by means of nuclear explosives and utilization of radiotracers in rating high-head pumps and turbines.

The final chapter in the report describes the present functions of the Department's radiological protection program.

Chapter I - INTRODUCTION

Recognizing the useful role which can be played by the application of radioisotopes to engineering activities, the Department of Water Resources first made use of radioactive materials as long ago as 1957. At that time radiation applications were just emerging from their earlier status as laboratory curiosities. Demonstrably beneficial results of radioisotope uses had been obtained by the late 1950's, a decade after they were introduced.

Bulletin No. 144-68* described about twenty-five of the Department's water resources-related activities in which radioisotopes have played a part. The significant benefits of radioisotopes already being achieved are generally recognized as indicative of the ultimate value of nuclear methods yet to be applied to the Department's water resources development program.

This report describes current progress in radiation-related activities. Radiological applications in which the Department has participated during the past year may be conveniently divided into three categories:

Soil moisture-density gauges
Isotopes as tracers
Nondestructive testing

The report's final chapter discusses the Department's radiation protection program. This function is required under the provisions of the Department's Radioactive Material License, which permits possession and use of radioactive material.

---

* "Radiological Applications Program - Annual Report for FY 1967-68", DWR Bulletin No. 144-68, September, 1968.

Chapter II - RADIOLOGICAL APPLICATIONS

SOIL MOISTURE AND DENSITY GAUGES

Rapid, precise, portable, nondestructive -- these are the characteristics of the radiation scattering technique for soil moisture and density determination that make it valuable for a number of water resources-related applications. The nuclear method is admirably suited to determining rate of water use by a crop or compaction in an earth fill. This is because it permits repeated accurate measurements of moisture content or density changes over a long period of time to virtually unlimited depths of soil.

Description of the Nuclear Method

A detailed description of the nuclear method for determining moisture and density, contained in Bulletin No. 144-68, may be briefly summarized as follows:

> Soil moisture and density gauges consist of four interconnected components: 1) a sealed source of radiation, 2) a radiation detector, 3) a device for converting the detector's signals into recordable count rates, and 4) a power supply. The detector is designed to respond exclusively to radiation which has been affected by that characteristic of the medium which is to be measured. When the source and detector are placed at the point of measurement, and the counting device started, a reading can usually be obtained within one minute or less. By means of a suitable calibration table, the appropriate moisture or density value can then be recorded. The device is then repositioned and another reading obtained immediately. The portable device can easily be moved by one man to several measurement locations in the field.

Nuclear Gauge Applications

Vegetative Water Use

Neutron soil moisture probes have been used principally in the San Joaquin District by the Land and Water Use laboratory in Bakersfield, which has continued to develop

and accumulate information on vegetative water use. The laboratory also functions as the key station for testing potential improvements in techniques and instruments that might eventually be used statewide.

The principal radiological accomplishments of the Bakersfield laboratory during the past year have been:

> Soil moisture depletion measurements to determine evapotranspiration rates of a plot of table grapes and a plot of mechanically harvested canning tomatoes. The grapes were measured twice a month and the tomatoes were measured approximately once a week. Eight moisture profiles were obtained.
>
> Development of a technique to determine evapotranspiration rates for shallow-rooted crops by measuring applied irrigation water and increase of soil moisture in initially dry soil profiles. A memorandum report, "Consumptive Use of Water by Spring Potatoes", describing this work in more detail, was published in May 1969.

During the year, a new model of portable scaler, a component of the nuclear moisture gauge, was delivered to the Bakersfield laboratory. This instrument weighs less than the earlier scaler and is easier to maintain. However, the new scaler's greater ability to resolve pulses arriving at a rapid rate proved to be somewhat of an inconvenience. Its higher rate of resolution results in a higher apparent count rate for high moisture content soils than was obtained when the previous system was originally calibrated. Extremely careful field measurements of soils in this high moisture range were necessary to revise the existing calibration curves. At year's end, data which will become the input for the revised calibration were being processed for the computer.

Joint investigations of vegetative water use utilizing neutron probes have been conducted with the University of California, Davis, and the U. S. Bureau of Reclamation, Fresno Field Division. Photographs of one of the Bureau of Reclamation's installations are shown in Illustration 1.

The Department also contributes to the support of investigations by the Soil and Water Conservation Division, Agricultural Research Service, Southwest Branch, at Lompoc, California, which used neutron moisture meters in two investigations during the year.

One of these investigations employed neutron moisture meters to measure deep penetration of rain water at naturally vegetated and artificially denuded sites. These data permit estimation of the amount of water penetrating beyond the root zone. From this information, methods are being developed to predict natural groundwater recharge by means of vegetative, soil, and climatic parameters in a computer model. Results obtained last year with the neutron moisture meter gave clear indications of the passage of soil moisture waves downward through the profiles. The data

Illustration 1 SOIL PERMEABILITY STUDIES, U. S. BUREAU OF RECLAMATION, FRESNO, CALIFORNIA

View of permeability test pit sheltered from precipitation by plastic cover.

View into permeability test pit.

View across permeameters in which barley crop is being grown.

also showed that in one 19-foot profile a depletion phase occurs at lower depths in the profile at the same time the accretion phase of a succeeding cycle is penetrating the upper part of the profile. In one instance, two annual accretion phases were measured simultaneously in one profile.

Another investigation conducted last year by the Agricultural Research Service under sponsorship of the Department of Water Resources had as its objective the determination of relationships between evapotranspiration and various climatic, soil, and plant influences. To develop a greater understanding of the evapotranspiration process, periodic neutron meter measurements are made of soil profile water contents in native vegetation. From these measurements the effects of changes in vegetation (burning off brush, mechanically clearing land) on soil moisture profile conditions may be determined. The amount and distribution of precipitation permit study of the source and movement of soil moisture. For example, in a year of lower than normal rainfall, it is possible to measure the quantity of moisture carried over from previous years which has been used in the evapotranspiration process.

Soil Salinity Studies

Nuclear soil moisture gauges are also used in soil salinity studies. Such an application during the year occurred in the Suisun Marsh study, a joint undertaking by the Departments of Water Resources and Fish and Game as part of the Delta Fish and Wildlife Protective Study. The objective of the marsh study is to determine the effect of changes in channel salinity upon the soil salinity and hence upon the forage and migratory bird population. Changes in the salt load will affect forage production, which in turn affects the migratory bird population.

Because the soils are highly organic, gravimetric determinations of soil water content are questionable when accomplished by the oven-drying procedures normally used for mineral soils. Although the quantitative soil moisture results obtained with the neutron probe in organic soils are not as reliable as those obtained from a probe in mineral soils, changes in soil moisture which may be determined by repetitive measurement of the soil moisture profile are reliably indicated. Soil moisture changes are required to determine the change in salinity from data obtained with electrical conductivity probes at the same time, date, and location. Additional data are also being obtained on the volume weights or densities of these soils through mathematical calculations based upon the soil moisture and electrical conductivity readings. Illustration 2 shows some of the field activity required for this study.

Without doubt neutron soil moisture meters have been of great benefit in this measurement program. Data of comparable reliability could not have been obtained at a reasonable cost without these instruments.

The past fiscal year has been one of concentration on the data collection program. Although a report on the Suisun Marsh investigation will be completed by December 1969, the field measurements are expected to continue well into the 1969-70 fiscal year and the data obtained thereby included in a supplemental report.

Illustration 2 DELTA FISH AND WILDLIFE PROTECTION STUDY

Overall view of instrumented study site at Joice Island (DWR Neg. 3722-1).

Simultaneously measuring salt concentration with conductivity meter and soil moisture content with neutron meter (DWR Neg. 3722-28).

Aluminum boat transports recording instrumentation. White polyethylene shield (right of center) provides additional personnel protection. (DWR Neg. 3722-24).

Compaction Control

Following completion of the Thermalito Forebay-Afterbay embankment in the fall of 1968, the Department's nuclear compaction control equipment was moved to the North San Joaquin construction project at Byron. These instruments were intended principally to assist in controlling density of the soil-cement to be placed on the Clifton Court Forebay embankment.

Precise control of moisture and density is absolutely essential in soil-cement construction, because the surface application is used in place of riprap and is occasionally subjected to high wave forces. Supplemental moisture and density data provided by the nuclear devices should contribute to better control of the embankment. Unfortunately, last winter's high water delayed placement of soil-cement. The work had barely commenced by the end of the fiscal year. Therefore, very little use of the nuclear devices was possible. They will, however, be used as required from the present through the completion of the embankment.

RADIOTRACER APPLICATIONS

Because of their extreme sensitivity and specificity, isotopic tracers are particularly valuable tools for following the pathways taken by a material through its environment.

Radioisotopic tracers are thus useful in water resources-related activities. Although no new tracer applications were initiated in Department activities during the year, progress in some of the continuing investigations was followed with interest.

Littoral Transport Studies

The Department of Water Resources has been directly involved in a continuing series of tests in which radioisotope-tagged sand is used to determine the mechanics of offshore movement of sediment, particularly around headlands. This study, called RIST (Radioisotopic Sand Tracer Study), is under the combined sponsorship of the U.S. Air Force, the U.S. Navy, the U.S. Army, and the Department of Water Resources.

The basic objectives of the RIST study are to develop methods and equipment for measuring sand transport and to obtain data that can be used to solve engineering problems related to maintaining coasts and waterways. These data would result in more precise knowledge of the characteristics of littoral material transport around headlands or supposed natural barriers to littoral drift, particularly sediment movement in the nearshore and offshore zones. Information will also be obtained on seasonal changes in rate, direction, and distance of littoral transport; average velocity of transport along a straight beach and around a headland; and the fundamental mechanics of sediment transport.

The procedure is to label ("tag") with a radiotracer about 100 pounds of sand removed from the beach under study. The tagged sand is then deposited in the surf at high tide and its movement is followed by four scintillation detectors housed in a 300-pound cylindrical device that rolls along the bottom as it is towed behind an amphibious

vehicle. The underwater mobile detector system and the ancillary computer and data treatment programs were developed by and are operated during field tests by Oak Ridge National Laboratory.

In the past fiscal year, three offshore injections of tagged sand were made. The first series of tests was conducted at Surf, California, in September and October, 1968. These operations were based on a laboratory study made on a model beach in May, 1968. This model study proved valuable because the field work turned out to be the most successful to that date.

In the first field test, a line source was constructed to extend from the beach face parallel to and through the surf zone. This was done by placing discrete samples of sand labelled with radioactive xenon in water-soluble bags at about 15-foot intervals. In the first test with this line source, an injection of 40 liters of sand was made under relatively calm conditions. In four days of monitoring, little movement was observed except along the beach face. In a second test, the waves were higher and the 40 liters of sand was rapidly dispersed. Two subsequent tests in which radioactive gold was used to label the sand gave generally the same results. Patterns were recorded for a distance of 2,500 feet, although actual surveys covered approximately 2 percent of the total offshore area involved.

In February, 1969, radioactive gold was used in a field test conducted near Point Conception, California, offshore from Vandenberg Air Force Base. The test was proceeding most satisfactorily when an unfortunate mechanical breakdown of the detector vehicle prevented most of the planned measurement program. Photographs taken at the time of this test are shown in Illustration 3.

A third test also utilizing gold-tagged sand was conducted during the week of June 16, 1969. This test appeared to proceed without difficulty, and at fiscal year's end the data obtained therefrom were being analyzed.

The project is progressing in orderly steps. Although as yet no quantitative measurements of gross littoral drift have been made, each experiment provides valuable information that improves the next measurement. As each phase begins, these improvements are evidenced by more sophisticated equipment, greater confidence of personnel in handling the equipment and the data, and generally much more reliable results.

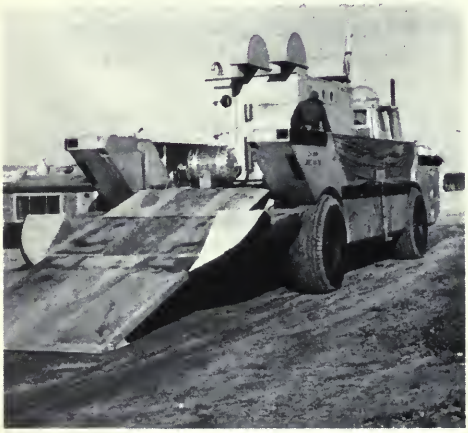
Other Radioisotope Tracer Projects

Although the Department of Water Resources currently has no official direct involvement in them, a number of water resources-related activities wherein radioisotopes are utilized merit close attention.

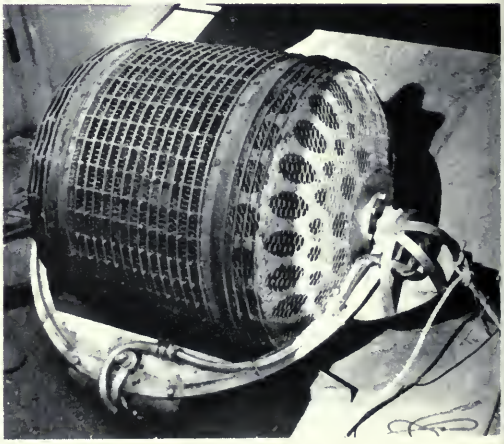
Snow Management Research

For a number of years, the U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, has been conducting snow management research into methods for studying and solving such problems as delaying total water yield. The research has resulted in development of a remote-controlled in situ snow

(Right) Loading ramp being lowered on LARC XV amphibious vehicle. These vehicles are capable of riding out a 10-foot surf.



(Left) Mobile detector vehicle and instrument shelter on deck of LARC XV vehicle.



(Right) Mobile detector vehicle containing scintillation detectors and auxiliary circuitry. Rocks on sea bottom dented the surface reinforcement rods.

AT SURF, CALIFORNIA, FEBRUARY 1969

(Left) Mounted on bow deck of LARC XV, shielded container holds water-soluble plastic containers of sand tagged with radio-gold.

(Right) On-board instrumentation includes (from left) 400-channel pulse-height analyzer and radiation detection equipment, navigational equipment, and print-out devices.

(Left) Dr. David B. Duane of U. S. Army Engineers, RIST project director, tosses dye marker into surf to determine feasibility of dropping tracers. Photo taken approximately 20 feet above sea level.

density gauge. Measurements obtained with the gauge are permitting development of predictive formulas for linking solar radiation with snow melt. The data have shown that snow melts at densities lower than those commonly believed necessary to produce melt. The system is being prepared for the computer to provide direct read-out of the numerical values of interest.

Radiotracer experiments designed to measure movement of water downslope in snowpacks have shown that large quantities of water move through dense snow layers inside the pack. Heretofore, the water was thought to pond on such layers and run downslope on top of even denser layers. The position of the water and its speed affect the rapidity with which it reaches the streams.

The Department is watching work now underway to develop a radioisotopic method to quantitatively evaluate water movement in trees. Radioactive phosphorus in water solution is introduced into mature pine trees through freshly cut root tips. The tracer moves up the trunk in a discrete narrow band, and its progress is followed quite easily by portable survey equipment. The position and extent of tracer movement is also occasionally checked by making autoradiograph pictures of the cross section of trunks of tracer-treated trees that have been cut down. Microscopic thin-section specimens are also obtained to show the extent of physiological structures that transport the tracer-treated water. According to Forest Service reports, these experiments produced estimates of water use by individual trees that are in marked agreement with values obtained from measurements of inflow and outflow for an entire watershed.

From these preliminary results it is apparent that additional development of the radioisotopic water movement method would be desirable. With further study, this tree tracing technique might some day prove useful as one of the methods for the collection of data used in watershed management studies.

Radioisotope Flow Measurements

The U. S. Bureau of Reclamation is continuing to improve methods for measuring flow rate in high-head turbines and pumps. A series of measurements has been completed at Flatiron Powerplant, Colorado, on a 6-foot-diameter turbine penstock and an 8-foot-diameter pump-turbine pipeline. Radioactive bromine has been used to make several measurements of discharge values, with sufficient success to encourage further work.

The project will be continued by applying the equipment in a series of demonstration measurements in a few selected power and pumping plants under the jurisdiction of the Bureau of Reclamation. Progress in these demonstration projects will be followed with interest by the Department of Water Resources.

Neutron activation is a widely used and rapidly developing laboratory technique for elemental analysis, but field applications are as yet less common. Using neutrons to induce radioactivity into an otherwise stable material and tracing the movement of the material by detecting the gamma radiation it subsequently emits has certain marked advantages over conventional methods. The relatively high penetrating power of both the incident neutrons and the emitted gamma rays makes feasible

the tracing of fluids moving in a great variety of media and minimizes sampling errors or interference due to changes in chemical composition. Although only preliminary results have been reported so far, there is reason to believe that a practical system can be developed to apply the neutron activation technique to water flow measurement.

One recent development which may go a long way toward making neutron activation feasible is the commercial production of californium-252. This man-made radioisotope emits neutrons spontaneously and intensely. It can be used in remote environments because it requires no maintenance, no elaborate control system, and no power supply. The AEC* indicates that "Although less than 50 milligrams of californium-252 are now in existence, several grams will be produced in the early 1970's and hundreds of grams could be made available by 1980. A few micrograms are sufficient for many applications."

The neutron activation analysis technique, with special regard to developments in the use of californium-252, will be carefully observed for its potential in water resources applications, particularly in water flow measurement.

Underground Nuclear Explosives

Use of nuclear explosives has been considered as an alternative to conventional engineering means in water resources development. However, many problems stand firmly in the way of its use for this purpose in the near future. In addition to somewhat limited information on certain technical aspects of the detonation, stringent environmental, economic, and legal limitations also exist.

It has been suggested that nuclear explosives might be used in construction for intercepting the natural movement of water, for detaining water in storage, or for conveying water. Also, the principal effect of nuclear detonation most likely to be useful to conserve and store ground water would be the rubble-filled collapse chimney that ordinarily results from a fully contained underground detonation. The chimney might function in four principal ways: 1) In a zone where a confining bed constrains the water, it might provide a highly permeable conduit, thus enlarging or prolonging the water yield from the aquifer system; 2) It might act as a "big well" to present a very large infiltration surface to the aquifer, thus increasing recoverable yield, facilitating recharge, or allowing injection of fluid waste products at suitable depths below land surface; 3) If it creates a suitable subsidence crater at land surface and reaches down to a saturated zone, it might help store surface runoff and help accelerate recharge of the zone; and 4) In massive impervious rock, it might afford underground void space for storing usable water. This last would be practical only if not restricted by the cost per unit volume of space.

Although the concept of creation of new underground voids capable of storing ground water appears extremely attractive, it must be remembered that to date a nuclear

*"Californium-252, Its Use and Market Potential". Brochure published by USAEC, Savannah River Operations Office, Aiken, South Carolina. May, 1969.

device has not been detonated with the specific objective of providing underground storage of water. No reliable data based on controlled testing exist that can be used to evaluate certain problems in California. For example, how effective would deep nuclear explosions be in the relatively shallow saturated ground water reservoirs in California? Will confining clay layers, severed or shattered by nuclear explosions, tend to stay apart or will they blend together with time and tend to seal deeper aquifers? What size cavities can be developed, and how many acre-feet of usable new underground storage capacity can be created? What are the total costs of storing water underground by use of nuclear devices, as compared to conventional artificial recharge projects? How does one evaluate the impact of detonating nuclear devices in populated areas? What systems must be established for payment of any damages to man-made structures which might result from shock waves generated by nuclear explosives? Will a nuclear device exploded near one of California's many active faults trigger an earthquake?

Some consideration has been given to using underground nuclear detonations to drain excess water collected this year in Buena Vista and Tulare Lake basins in San Joaquin Valley. However, geological and hydrological conditions in the saturated sedimentary materials beneath the valley floor do not appear favorable for creation of large new underground storage spaces.

The Aquarius study, which is an investigation of the feasibility of applying nuclear explosives to improve the ground water supply in Arizona, began during the past year. It is being conducted jointly by the Atomic Energy Commission and the Department of the Interior, in response to a request by the Governor of Arizona. Results of the study will be read with interest.

More definitive information should result from test detonations that currently are pending in other resource fields, such as natural gas. Beyond that, progress toward general understanding and possible acceptance of nuclear detonation in the field of water seems to rest on an experimental detonation of some demonstrably simple modification of a natural hydrologic feature.

Chapter III - RADIATION PROTECTION PROGRAM

INTRODUCTION

Use of radioactive material is limited by specific regulations set forth by the U. S. Atomic Energy Commission. The authority to regulate possession and utilization of radioactive material has been delegated by federal law to the governments of a number of states. In California, the regulatory agencies are the Department of Public Health and the Division of Industrial Safety.

SUMMARY OF DEPARTMENT ACTIVITIES

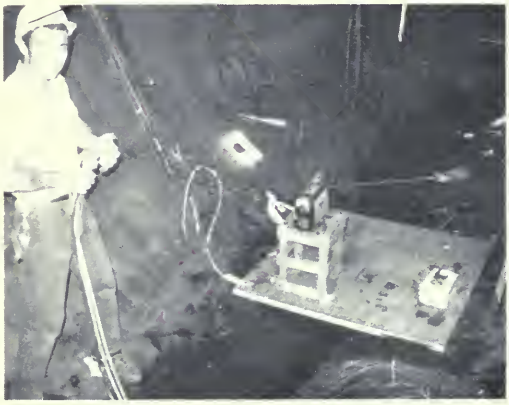
Authority for supervision of radioactive material in the Department of Water Resources is vested in a Radiological Operations Officer whose duties and responsibilities for the radiation protection program have been discussed in detail in Bulletin No. 144-68. The following activities were carried out under the jurisdiction of the Radiological Operations Officer during the past fiscal year:

1. The Department of Water Resources' Radioactive Material license, bearing an expiration date of April 23, 1969, was renewed on June 9, 1969. The new license, which expires April 23, 1974, includes six radioisotopes, a total of nearly 2,800 millicuries contained in 27 sealed sources.

2. A number of amendments to the Department's Administrative Manual's radiation safety section were submitted. These were approved and released by the Department's Management Analysis Office in October, 1968. In June, 1969, an extensively revised version of this section was submitted through channels for approval. These revisions are intended not only to update the regulations but to put the section on specific radiological protection rules in a more convenient booklet form.

3. In November, 1968, a 2-day training program qualified 13 new Radiological Operators in accordance with provisions of the Department's Radioactive Material License. At the 1968-69 fiscal year's end, a total of 17 active Radiological Operators had been trained and were fully

Illustration 4 RADIOGRAPHIC OPERATIONS IN WELD INSPECTION



Radiography on Edmonston pumping plant discharge line showing remote control cable connected to a shield containing radioactive source (on wood crate). Radiation survey meter visible on platform next to crate.

Operating remote control source positioning device, Wind Gap Pumping Plant discharge line. Cables pass through inspection port at right.

Operating remote control source positioning device, Angeles Tunnel surge chamber. This device is connected to shield in background, photo to right.

Arrow 1 shows position to be occupied by radioactive source when run out on cable from shield in background; arrow 2 shows reinforcing steel weld wrapped with a film packet.

qualified to work with radioactive materials in specific Department programs.

4. The number of individuals subject to film badge monitoring requirements grew during the year from 40 to nearly 70. This increase stemmed primarily from an interpretation of the State radiation protection regulations made by the Division of Industrial Safety in April, 1969. The DIS interprets the language of the personnel monitoring regulation to include in the film badge monitoring program Department inspectors who might inadvertently be exposed to radiation. Photographs of some of the operations required in radiographic weld inspections are shown in Illustration 4. As an additional safeguard for our personnel, five kits containing portable survey meters and pen-type self-reading pocket dosimeters were distributed to the following divisions of the Department:

South San Joaquin Division
- Wind Gap Pumping Plant
- A. D. Edmonston Pumping Plant

Tehachapi-West Branch Division
- Angeles Tunnel
- Angeles Tunnel Surge Chamber
- Castaic Dam

Provision has been made for supplying welding inspectors in the Mojave-Santa Ana Division with similar kits during the next fiscal year, when radiography of welds begins. These survey instruments are in addition to those with which gauging operations are conducted by Radiological Operators in the Northern District, Red Bluff; in the San Joaquin District, Fresno and Bakersfield; in the Central District, Sacramento; at the Technical Services Office, Bryte; and in the North San Joaquin Division, Clifton Court Forebay.

5. The Department entered the 10th year in which its personnel and contractors incurred neither reportable injury nor overexposure to radioactive material. The film badge records did indicate four instances of small but significant exposures received by individuals being monitored. Although the amounts of radiation recorded did not exceed the statutory limit, or even the administrative guidelines set forth in the Department's Administrative Manual, informal investigations were nonetheless conducted by the Radiological Operations Officer, and steps initiated to lower the average exposure of these individuals.